Productivity and Density of Belted Kingfishers on the Housatonic River

PREPARED FOR

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Appendices

1.0 Introduction

Between the 1930s and 1977, polychlorinated biphenyls (PCBs) were used in manufacturing processes at the General Electric Company facility in Pittsfield, Massachusetts. Prior to 1977, releases of PCBs were conveyed to the Housatonic River and subsequently deposited in downstream sediments. Small fish (e.g., 4 to 14 cm in length) and crayfish inhabiting the river have accumulated relatively high concentrations of total PCBs [26 mg/kg $\pm$ 0.73 (mean + SE), n=212] (Weston 2002).

As an obligate piscivore with a relatively small foraging range, the belted kingfisher (*Ceryle alcyon*) offers a model for evaluating the ecological effects of bioaccumulative chemicals, such as PCBs, in riverine systems (Landrum et al. 1993). While other researchers have evaluated exposure of kingfishers to PCBs without considering reproductive outcome or *vice versa* (e.g., Heinz et al. 1984, Brooks and Davis 1987), this is the first known study to evaluate kingfisher productivity *in situ* in a system with known PCB contamination. We monitored productivity of kingfishers breeding on or near the Housatonic River between the confluence of the East and West Branches and Woods Pond Dam (hereafter referred to as the study area) (Figure 1) and compared our observations to those reported in the literature. We also tested whether estimated PCB dose, habitat quality, phenology (i.e., timing of breeding cycle), and/or nest density were significant predictors of reproductive success. A reference area was not included in this study due to the lack of comparable habitat nearby. Reproductive success was instead evaluated by comparison with results of published studies at uncontaminated sites and by testing for evidence of dose-response relationships within the range of estimated doses for the study area.

Belted kingfishers are medium-sized (28 to 35 cm long; 140 to 170 g) birds with stocky blue-gray bodies and a conspicuous, ragged double crest on their heads (Hamas 1994). Their preferred habitat includes open running waters that are neither turbid nor obscured by vegetation. Fish dominate their diets, although mollusks and crustaceans are also regularly consumed (Prose 1985, Landrum et al. 1993, Hamas 1994). Minor components of the diets of kingfishers include insects, amphibians, reptiles, young birds, small mammals and berries (Hamas 1994). Most fish are caught within the upper 60 cm of water and range from 4 to 14 cm in length (Davis 1982, Hamas 1994, Kelly 1996). Pairs are seasonally monogamous and males are extremely territorial. Prose (1985) estimated that the minimum habitat area required per pair is 1 km of stream, while other researchers report breeding season territories up to 2.6 km in length (Cornwell 1963, Davis 1982, Brooks and Davis 1987, Landrum et al. 1993). Nest chambers are constructed in 1 to 2 m deep burrows usually dug at least 2 m above the surface of the water in high sandy cut banks devoid of vegetation (Hamas 1994, Baron et al. 1997). Generally, only one clutch of eggs is laid per year, but a second clutch may be laid if the first nest is destroyed early in the breeding season. Clutches generally consist of 5 to 7 eggs and incubation lasts 22 to 24 days. Nestlings fledge 27 to 29 days after hatching (Hamas 1994).

2.0 Methods

This study involved: a) identifying active kingfisher burrows along the banks and riparian zone of the Housatonic River study area; b) monitoring breeding pairs from courtship through fledging using a Peeper Probe™ video system (Sandpiper Technologies, Manteca, CA); c) collecting nest remnants left after fledging to characterize predominant prey; d) characterizing the suitability of available habitat for breeding kingfishers, using the U.S. Fish and Wildlife Service's habitat suitability index (HSI) model (Prose 1985); e) comparing observations to the scientific literature for kingfishers; f) estimating doses of PCBs for adults and nestlings, based on available data on concentrations of total PCBs in crayfish and whole fish of appropriate size that were previously collected within foraging distance of each burrow; and g) testing whether the estimated dose of PCBs, HSI score, hatch date and/or nest density were significant predictors of nest outcome (i.e., successful nests[1]) and/or the number and percent of nestlings to survive to 26 days. Survival to 26 days was used as a surrogate for fledging success, in an effort to avoid losing data if nestlings fledged early or if fledging was not witnessed. Although a pilot study of the field work was completed in 2001, the majority of data were collected in 2002.

2.1 Monitoring Methods

Searches for active kingfisher burrows targeted banks and the riparian zone of the study area. Searches were conducted by canoe, automobile and foot early in the breeding season (i.e., starting 8 May 2002). Burrows were photographed and mapped

[1] Successful nests were defined as those that fledged at least one young. Unsuccessful nests were defined as those that were depredated. One burrow that was destroyed by heavy equipment was not included in the analyses.

using a hand-held Global Positioning System (GPS) unit (GARMIN GP-12, GARMIN International Inc., Olathe, KS).

All identified nests were monitored every two to three weeks using the Peeper Probe system. The Peeper Probe system consists of a video camera attached to the end of an articulated 4 m long gooseneck probe, a head-mounted display, battery, and videocassette recorder and monitor (Photograph 1). We visited each burrow every two to three weeks in order to minimize disturbance and possible abandonment of nests, while collecting data during each phase of breeding (i.e., egg laying, incubation, hatching and fledging). We recorded information on the bank and the burrow, as well as nest status, number of eggs, number of nestlings, age of nestlings, and parental behavior.

The Peeper Probe allowed video documentation of the number of nestlings and the age of the nestlings. However, during the incubation stage, females generally prevented a clear view of eggs. Hence, while nests were observed at this stage, we could not collect data on either clutch size or hatching success.

We inspected completed nests for remnants of prey. Nest remnants were only found in one destroyed burrow during the pilot study conducted in 2001. In 2002, remnants were collected from seven nests after the nestlings had fledged or nests were depredated. Those remnants were collected to allow identification of the age and species of prey consumed by resident kingfishers. We removed remnants from each burrow using a stainless steel ladle. Remnants were placed in chemically precleaned sample containers, which were then labeled with respect to date, burrow identification number, sample identification number and person sampling. R2 Resource Consultants (Redmond, WA) rinsed the samples in water, sieved them (63 µm mesh), composited the samples into a single sample, and sorted the contents under a dissecting microscope to determine species and age of prey.

2.2 Evaluation of Habitat Suitability

Habitat suitability was evaluated in general accordance with the HSI model for kingfishers (Prose 1985). This model consolidates habitat use information into a framework appropriate for field application, and is scaled to produce an index between 0.0 (unsuitable habitat) and 1.0 (optimum habitat). Scores of 0.6 and higher are generally considered indicative of good quality habitat.

Field data required for the model include: average water transparency (i.e. Secchi depth); percent water surface obstruction; percent of water area that is greater than or equal to 60 cm in depth; percent with riffles (i.e., shallow turbulent reaches with nonlaminar flow); average number of stream subsections that contain one or more perches; and distance to nearest suitable soil bank from 1-km sections of stream. In order to determine the suitability of individual banks, slope, vegetation, height and soil texture are considered.

Although all data collected for the HSI model are quantitative, some subjective judgments are inevitable in, for instance, estimating percent surface obstruction and determining which tree branches qualify as perches. To minimize potential bias associated with subjective judgments, one field biologist made measurements for all river segments and he made every effort to apply the method consistently throughout the study area.

The study area was divided into 1-km segments (Figure 2). Field data were collected on 25 June and 9 July 2002, which coincided with the nestling period for most nests. Because percent riffles varied with season (i.e., increasing as water levels dropped in summer), the HSI data collected represented the middle of the breeding season, but not the end of the breeding season.

We recorded habitat characteristics of every 1-km river segment within the study area. Measurements were taken from a canoe with a trolling motor. Within each station, we estimated and recorded the percent of the water surface with riffles, the percent of the water surface that was obstructed (such as by overhanging or emergent vegetation, logs, bridges, etc.), the number of potential perches present, and the locations of banks. From the approximate center of each segment, the average Secchi disk depth over five readings was determined by placing the disk in the water and allowing it to descend to a depth where it was no longer visible.

The percentage of each segment with a depth greater than 60 cm was estimated as follows. For the main river channel, bathymetric cross sections taken in 1998 were used for depth estimates. National Geodetic Vertical Datum (NGVD) elevations were converted to water depth based on an estimate of the mean surface water profile at an average flow rate of 4.53 cubic meters per second (measured at the United States Geological Survey gage in Coltsville, Massachusetts). For each transect, the fraction of its length that was greater than 60 cm deep (perpendicular to river flow, from shore to centerline) was calculated. This percentage was then averaged for all transects contained within a given sampling segment. A similar approach based on weighted averages was used for the backwater regions. For Woods Pond, bathymetry contours of water depth prepared by CR Environmental, Inc. (1998) were used to estimate the percentage of each sampling segment that was greater than 60 cm deep.

Data analysis for the HSI model followed Prose's (1985) method. Graphs presented by Prose (1985) relate each of the field measurements to suitability indices ranging from 0.0 to 1.0. We used the slopes and Y-intercepts from those graphs to determine the equations for the lines that relate field measurements to suitability indices[2].

SIV2 = Secchi depth (cm) ÷ 60

SIV3 = 1.0 + percent surface obstructed x (-0.01)

SIV4 = 0.25 + percent water area greater than 60 cm deep x 0.0075

SIV5 = 0.20 + percent riffles x 0.027 (if 30 percent or less is riffled, as was the case for the study area)

SIV6 = 1.0 (if there are 40 or more perches per km, as was the case for the study area)

SIV7 = 1.0 + distance to nearest suitable bank (km) x (-0.33)

Prose's (1985) equations for calculating the water (SIW), cover (SIC), and breeding habitat (SIR) components for riverine environments are:

SIW = $(\text{SIV2 x SIV4 x SIV5})^{1/3}$ x SIV3

SIC = SIV6

SIR = SIV7

The overall HSI is equal to the minimum of SIW, SIC and SIR.

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[2] Because SIV1 is only applicable to lake environments, it was not considered in this analysis.

As an extension to the HSI evaluation, we selected a subset of all banks (n=157) in the study area for detailed evaluation. The nine banks with active kingfisher burrows were selected for evaluation, along with nine randomly selected unoccupied banks. The suitability of those 18 banks was evaluated with respect to its slope (i.e., vertical or overhanging), the absence of vegetation, height, and soil texture. The "feel" method (Hays et al. 1981) was used to determine whether the soil was predominantly clay or sand.

2.3 Estimation of PCB Doses

We estimated PCB doses based on the concentration of PCBs in crayfish and whole fish collected by the U.S. Environmental Protection Agency (EPA) and General Electric (GE) from the study area (Weston 2002). Those data are presented in Appendix A. As illustrated in Appendix A, this dataset specifies the data source (i.e., EPA or GE), sample identity, location, river mile, burrows located within 1,200 m of sampling location, date collected, species, sample type (i.e., composite or individual), number of individuals in composite, average length of fish in sample, concentration of total PCBs (in ppm, wet weight), and analytical method (i.e., EPA Method 1668 for congeners or EPA Method 8082 for Aroclors).

For purposes of estimating dose, we assumed an average territory size of 2,400 m (i.e., 1,200 m upstream plus 1,200 m downstream of the burrow), which is consistent with the lower end of the range reported by Landrum et al. (1993) as well as observations made by Brooks and Davis (1987) in Pennsylvania. Although breeding season territories may be greater than 2,400 m in total length, kingfishers are expected to concentrate their foraging fairly close to the nest in order to minimize unnecessary energy expenditure and to defend young from predators. Given this assumed territory size, samples representative of the preferred prey of kingfishers -- i.e., crayfish and fish ranging in length from 4 to 14 cm (Davis 1982, Hamas 1994, Kelly 1996) -- that had been collected from within 1,200 m of an active burrow were included in the dataset.

EPA and GE collected fish samples by electroshocking in the fall between 1994 and 2000 (Weston 2002). Based on the movement of fish within in the river and the method of transect sampling associated with electrofishing, river mile designations shown in Appendix A for fish samples were assumed to reflect a sampling area that extended from one-half mile upstream of the listed river mile to one-half mile downstream, as illustrated in Figure 3. Fish sampling locations were generally well within 1,000 m of a burrow or well beyond 2,000 m of a burrow, so assignment of samples to burrows was unambiguous. Crayfish samples were collected using baited traps in deep water and hand nets or seine nets in shallow water (Weston 2002).

Use of the available dataset for estimation of representative prey concentrations assumes that: a) kingfishers breeding within the study area consume crayfish and various species of fish in the same proportions that they are included in the dataset; b) PCB concentrations in prey in 2002 are consistent with sample results from 1994 to 2000; and c) kingfishers obtain 100 percent of their diet from the study area. Although the use of an assumed, rather than measured, territory size to select representative fish and crayfish samples introduces some uncertainty into the estimation of dose, the alternative of collecting prey directly from the kingfishers would have likely caused nest abandonment. For this reason, indirect estimation of dose based on historic fish and crayfish sampling data was judged preferable to direct measurement of dose for purposes of this study.

The reported concentrations of total PCBs in fish and crayfish were multiplied by reported prey ingestion rates for adults (0.5 g/g-day per Alexander 1977) and fledglings (1.375 g/g-day per White 1936) to generate estimates of daily doses of PCBs to kingfishers breeding within the study area.

2.4 Statistical Analysis

For statistical analyses, dependent variables were defined as nest outcome[3], number of nestlings to survive to 26 days, and percent to survive to 26 days. Independent variables were defined as estimated PCB dose, hatch date, HSI score, and number of burrows within 1 km (i.e., nest density). Statistical analyses were not completed for both the estimated adult and fledgling PCB doses, because these two measures differed by a constant equal to the difference between adult and fledgling prey ingestion rates. Hence, statistical findings would be identical for these two measures of exposure.

The effects of individual independent variables on the dependent variables were tested using Student t-tests and linear regression analysis. The effects of combinations of independent variables on the dependent variables were tested using multiple linear regression analysis.

[3] As previously noted, nest outcome was defined as either successful or depredated. In this study, all nest failures included in the analysis were due to depredation.

Statistical tests were conducted both including and excluding depredated nests. As discussed further below, one burrow that was destroyed by heavy equipment was excluded from all data analyses because its destruction was assumed to be unrelated to either PCB exposure or ecological factors.

In all cases, significance was evaluated at p=0.05. Mean values are reported with their standard errors (as mean ± SE). All statistical analyses were conducted using PASS for Windows (NCSS, Kaysville, UT).

3.0 Results

A pilot study of the monitoring component was conducted in 2001. That effort demonstrated the suitability of the Peeper Probe video system, as well as the need for more concerted efforts to find all possible active burrows. Of four kingfisher burrows identified in 2001, two were destroyed (by flooding and heavy equipment) prior to egg laying, one was destroyed by flooding prior to hatching, and one was depredated prior to fledging. Nest remnants collected from this latter burrow contained fish scales and bones, crayfish exoskeleton, and bird bones. All fish scales and bones were from young-of-year Cyprinids (minnows) and Centrarchids (sunfish) or Percids (perch). Although kingfishers reportedly consume birds on rare occasions, aquatic prey are clearly preferred, as evidenced by their bill structure and the literature (Prose 1985, Landrum et al. 1993, Hamas 1994). Hence, the bird bones in the 2001 nest remnant sample were more likely the remains of the kingfishers that had occupied that burrow than the prey of those kingfishers.

The results of the 2002 monitoring events are summarized in Table 1, while the field data sheets are provided in Appendix B. Figure 1 illustrates the locations of the active kingfisher burrows monitored in 2002. Photographs taken with the Peeper Probe during the monitoring program are provided in Photographs 2 through 29. The four burrows clustered near Woods Pond were located in a quarry operated by Lane Construction Company. Those burrows were discovered by watching the direction of departure of kingfishers foraging at Woods Pond. Hence, while it is possible that kingfishers breeding in the quarry also foraged downstream of Woods Pond Dam, they were clearly foraging at Woods Pond.

Of the nests monitored in 2002, one (M-WP) was destroyed by heavy equipment prior to egg-laying and three (G-KM07, M2-WP, N-KM16) were depredated before nestlings reached 26 days of age. One fledgling from nest H-KM08 was killed soon after fledging. Based on the appearance and accessibility of the depredated nests, as well as the appearance of carcasses (see, for example, Photographs 10 and 23), predators were likely a mustelid, a bird of prey, and a snake. It appeared that the pair whose first nest (M-WP) was destroyed by heavy equipment initiated a new nest (M2-WP) near the location of the first, soon after the destruction of their first nest. Data from the second nesting attempt were included in data summaries and statistical analyses, while data from the first nesting attempt were not. Because the two nests of that one pair are not independent data points, it is not appropriate to include both in the analyses. The first nest attempt was excluded because its destruction was a result of human interference, rather than factors related to either exposure to PCBs or ecology.

For the six successful nests, the average number of nestlings per nest was 4.8 $\pm$ 0.48 (mean $\pm$ SE) and the average number of nestlings to survive to 26 days was 4.2 $\pm$ 0.65. Percent survival to 26 days was 87% $\pm$ 9.9%. If depredated nests are also included in the analyses, the average number of nestlings per nest was 3.9 ± 0.66 and the average number to survive to 26 days was 2.8 ± 0.81. With the inclusion of depredated nests, percent survival to 26 days dropped to 58% ± 16%.

HSI scores for all 1-km river segments are presented in Table 2. Locations of all segments are illustrated in Figure 2. For all segments, the quality of the foraging habitat (SIW) was the limiting factor on the overall habitat quality. The overall HSI score for 1-km river segments with successful nests was 0.4 $\pm$ 0.09, while the scores for river segments with and without active burrows were 0.4 $\pm$ 0.03 and 0.3 $\pm$ 0.04, respectively. The HSI score for reaches with depredated nests was 0.3 $\pm$ 0.05. Study area-wide scores for the individual components of cover and nesting were 1 $\pm$ 0.0 and 0.9 $\pm$ 0.02, respectively.

There were minimal differences between occupied and randomly selected unoccupied banks, in terms of nest site suitability (Table 3). The probability of a burrow being dug in a bank deemed suitable by the HSI method (Prose 1985) was 53 percent, while the probability of a burrow being dug in a bank deemed unsuitable was 50 percent. Occupied and unoccupied banks had similar clay:sand compositions, as was expected based on the homogeneity of the lithology of alluvial cutbanks. All of the occupied banks were greater than 1.5 m high, while 66 percent of the unoccupied banks were greater than 1.5 m high.

The number of active burrows within 1 km of each burrow (i.e., nest density) was 2 $\pm$ 0.6 for the entire study area. As a result of dense settlement of kingfishers in the Lane Construction quarry near Woods Pond, however, the density of nests near Woods Pond

(4 ± 0.0) was an order of magnitude higher than the density of nests along the main stem of the river (0.4 ± 0.5).

Overall population density of breeding kingfishers was 9 pairs in 25 km (including river length plus shoreline of Woods Pond and backwaters) or 0.36 pair/km. The inclusion of shoreline of backwaters (which provide poor foraging habitat for kingfishers) in the total estimated length of shoreline may cause population density to be underestimated. Indeed, compared to HSI scores for 1-km segments in the mainstem (0.4 – 0.5), those for backwaters were very low. The one backwater with a score of 0.4 (BW05) is closely associated with Woods Pond (Figure 2). The other four backwaters had scores of 0.03 to 0.2. Excluding the backwater shoreline results in a density of 9 pairs in 18 km or 0.49 pair/km. This population density is assumed to be more representative of actual habitat use by study area kingfishers because it excludes backwater areas that do not represent suitable habitat. When calculated separately for the mainstem and Woods Pond, population density was 0.31 pair/km in the mainstem and 2.1 pair/km near Woods Pond.

Nest remnants collected in 2002 from seven burrows contained fish scales and bones, crayfish exoskeleton, bird bones and insects (an ant and an aphid). As with the nest remnant sample collected in 2001, all fish scales and bones were from young-of-year Cyprinids and Centrarchids or Percids. As previously discussed with respect to the 2001 nest remnant sample, the bird bones in the 2002 nest remnant sample are assumed to be the remains of depredated kingfishers, rather than their prey. Also, based on literature reports (Prose 1985, Landrum et al. 1993, Hamas 1994), the insects found in the nest remnant sample from 2002 were likely organisms living in the soil of the burrows, rather than the prey of kingfishers.

Estimated PCB doses for adult and fledgling kingfishers are summarized in Table 4. The estimated doses of PCBs (mean ± se) for adults and fledglings from all nests were 13 mg/kg-day ± 1.3 and 35 mg/kg-day ± 3.5, respectively. Estimated average doses of PCBs to adults inhabiting the nine active burrows ranged from 7.4 to 21 mg/kg-day. Estimated average doses to fledglings inhabiting the nine burrows ranged from 20 to 57 mg/kg-day.

Table 5 presents the results of statistical analyses conducted with depredated nests included. As noted above, the one nest that was destroyed by heavy equipment was excluded from all statistical analyses. No significant relationships were observed between estimated PCB dose and any of the reproductive endpoints ($p>0.05$). Figure 4 depicts the relationship between estimated doses of PCBs to adults and number and percent of nestlings surviving to 26 days. In addition, there were no significant relationships between HSI score and number and percent surviving to 26 days or between nest density and number and percent surviving to 26 days. A significant inverse relationship (p=0.036) was identified between percent surviving to 26 days and hatch date, indicating lower survival with later nest initiation (Table 5).

We also tested for combined effects between estimated PCB dose and HSI score, hatch date, and nest density, in an effort to determine whether individuals already stressed by ecological factors were more susceptible to the effects of PCBs. The multivariate models had no significant predictive power (p>0.05), indicating that no adverse interactions between PCB exposure and natural stressors were detectable (Table 6).

All statistical tests were repeated with depredated nests excluded from the dataset (Table 7). Again, there were no significant relationships between estimated PCB dose and any of the measures of reproductive performance (p>0.05), but the effect of hatch date on percent surviving to 26 days remained significant (p=0.013).

4.0 Discussion

Based on observations of nine active kingfisher nests conducted throughout the 2002 breeding season, the study area is supporting a kingfisher population consistent with the quality of available habitat. That population is breeding successfully, with productivity (i.e., survival of nestlings to 26 days) and population density consistent with expectations based on the scientific literature (as discussed below). Depredation was the cause of the three nest failures.

Of the available studies on kingfishers in the literature, only one (Brooks and Davis 1987) reported sufficient information on fledging success to support comparisons to our results. That study reported fledging success for kingfisher populations breeding in Pennsylvania and Ohio. Because the published study (Brooks and Davis 1987) reported fledging rates with depredated nests included, we obtained the original raw data from Brooks (personal communication, Robert Brooks, October 7, 2002) to allow evaluation of fledging rates with depredated nests excluded as well. Those comparisons are summarized in Table 8.

Due to the much higher rate of depredation in the Housatonic River study area (3/9 or 33.3 percent) than in the Pennsylvania (1/8 or 12.5 percent) and Ohio (0/6 or 0 percent) areas studied by Brooks and Davis (1987), fledging rates for the Housatonic River kingfishers were lower than those in Pennsylvania or Ohio when depredated nests were included. However, there is no reason to believe that depredation is related to PCB exposure and there was no significant relationship between estimated PCB dose and depredation (Table 5).

When depredated nests were excluded, fledging rates for the Housatonic River kingfishers were not significantly different from those observed by Brooks and Davis. The mean number of Housatonic study area nestlings to survive to 26 days was 4.2 ± 0.65, which is not significantly different from the mean number of Ohio study area nestlings fledged (5.3 ± 0.88, p>0.50) or the mean number of Pennsylvania study area nestlings fledged (5.1 ± 0.26, p>0.20). Likewise, the mean percentage of Housatonic study area nestlings to survive to 26 days was 87% ± 9.9%, which is not significantly different from the mean percentage of Ohio study area nestlings fledged (79% ± 13%, p>0.50) or the mean percentage of Pennsylvania study area nestlings fledged (91% ± 6.2%, p>0.50).

The kingfisher population density in the entire study area was 0.36 pair/km. A much higher population density was observed near Woods Pond (2.1 pairs/km), compared to the mainstem of the Housatonic River (0.31 pair/km). The higher density near Woods Pond would not have been predicted based on the HSI scores (Table 2), given that the three Woods Pond segments (WP01, WP02, WP03) had poor water habitat quality (i.e., no riffles). Compared to the mainstem, the Woods Pond area may have supported a higher density of kingfishers because it is within foraging distance of a riffled reach of the river that is downstream of the southern boundary of the study area (i.e., Woods Pond Dam). The quarry near Woods Pond also offers abundant suitable banks for nesting.

The observed population densities in the study area (i.e., 0.31 to 2.1 pair/km) were consistent with the range reported in the literature. Population densities in Pennsylvania and Ohio were 0.11 pair/km and 0.54 pair/km, respectively (Brooks and Davis 1987). Brooks and Davis (1987) observed that breeding densities along streams appeared to reflect the number of riffles to a greater extent than the availability of nest sites. Davis (1982) reported a density of 0.65 pair/km in rural southwestern Ohio and also remarked on the importance of riffles as habitat cues that influence the size of kingfisher territories. Other researchers (e.g., Hamas 1974, Godfrey 1986) reported that availability of suitable nesting sites was more frequently the limiting factor in defining density and territory size in kingfishers. Kelly and Van Horne (1997) reported a density of 0.67 pair/km in Fort Collins, Colorado. White (1953) reported a density of 3.13 pairs/km in agricultural districts of New Brunswick, Canada. In light of the relatively poor quality of foraging habitat in the study area (as evidenced by HSI scores well below 0.6), the observed densities of the kingfisher population exceeded expectations. For example, the population density in the Housatonic study area was greater than that of the study area in Pennsylvania studied by Brooks and Davis (1987), which Brooks reported had comparable quality habitat (personal communication, October 7, 2002). Because none of the reports of kingfisher density in the literature were accompanied by HSI scores, it was not possible to determine whether the reported high densities were associated with high quality habitat. However, that conclusion may be inferred from observations that territory sizes and habitat quality (particularly the presence of riffles and shallow water) are inversely related (Davis 1982, Brooks and Davis 1987). Furthermore, because field biologists striving to maximize sample sizes in their studies would logically seek out study areas with high quality habitat, literature reports would be expected to reflect systems with higher quality habitat than that of a system studied solely as a result of its historic contamination.

We observed no statistically significant relationships between estimated PCB doses and three measures of productivity (nest outcome, number surviving to 26 days, and percent surviving to 26 days) (Table 5). Failure to detect a PCB-related effect might be attributed to the small number of nests evaluated. However, we did observe a statistically significant relationship between productivity and phenology: percent of young surviving to 26 days decreased with later nesting, regardless of whether or not depredated nests were included in the analysis. Our observation of decreased productivity in broods raised later in the breeding season is consistent with previous findings on kingfishers (Kelly and Van Horne 1997), red-winged blackbirds (*Agelaius phoeniceus*) (Nero 1956, Crawford 1977), tree swallows (*Tachycineta bicolor*) (Stutchbury and Robertson 1988), song sparrows (*Melospiza melodia*) (Nice 1943), pied flycatchers (*Ficedula hypoleuca*) (Von Haartman 1967), and American robins (*Turdus migratorius*) (Howard 1967). The ability of our study to detect the expected effects of phenology on productivity suggests that the study was sufficiently sensitive to detect differences within the range of natural variability.

Several factors contribute uncertainty to this evaluation. First, although exhaustive searches were conducted to find kingfisher burrows along the studied reach of the Housatonic River, it is not known whether the burrows of all kingfisher pairs breeding there were in fact found. Second, because incubating females prevented viewing of eggs, it was not possible to obtain data on clutch size or hatching success. However, information on survival to 26 days is more ecologically relevant than on earlier stages of reproduction, as it has a more direct relationship with productivity (i.e., recruitment) of the local kingfisher population. There is high certainty regarding the number of nestlings present in each burrow, as the Peeper Probe afforded excellent views (and documentation) when adult birds were not present. Third, nest remnants apparently included prey remnants as well as remains of depredated kingfishers and indigenous terrestrial insects. While there is resultant uncertainty regarding the composition of diets of kingfishers in the study area, it is likely that their diet is almost exclusively aquatic (i.e., small fish and crayfish), consistent with the literature (Prose 1985, Landrum et al. 1993, Hamas 1994). Fourth, some subjectivity is associated with field measurements associated with the HSI model (i.e., percent surface obstruction, percent riffles, number of potential perches). To minimize potential bias associated with collection of HSI field data, we used one field biologist to collect all data, and he applied the method consistently throughout the study area. Finally, estimated doses of PCBs to kingfishers were calculated based on fish and crayfish data collected between 1994 and 2000. As part of this effort, it was necessary to estimate the foraging range of kingfishers in the study area, based on previous literature reports. Because foraging range varies with habitat quality (Davis 1982, Brooks and Davis 1987), there is uncertainty associated with the assumed foraging range of 2,400 m applied in this analysis. We also made the implicit assumptions that kingfishers consumed crayfish and various species of fish in the same proportions as they are included in the dataset and that prey concentrations in 2002 were consistent with analytical results from 1994 to 2000. Despite these uncertainties, indirect estimation of dose was considered preferable to direct measurement of prey samples, due to the likelihood of nest abandonment that might result from attempts to collect such samples.

5.0 Conclusions

In summary, the observations conducted in 2002 indicate that the study area is supporting a kingfisher population consistent with the quality of available habitat, and that that population is breeding successfully. Survival to 26 days (excluding the impacts of depredation) and population density for Housatonic River kingfishers appear to fall within the range of those reported for other kingfisher populations studied, and there was no statistically significant relationship in this study between estimated PCB dose and measures of kingfisher productivity. Thus, this study provides no evidence of impaired reproduction or population density due to PCB exposure for kingfishers breeding within the studied reach of the Housatonic River.

6.0 References

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Table 1. Summary of 2002 Monitoring Results

Burrow ID	Latitude	Longitude	Date of discovery	Hatch date	No. young	No. survived to 26 days	% survived to 26 days	Outcome
E-KM01	42 deg 25.757'	73 deg 14.917'	5/8/02	6/10/02	6	6	100%	Successful
G-KM07	42 deg 24.403'	73 deg 14.328'	5/8/02	6/26/02	4	0	0%	Depredated
H-KM08	42 deg 24.300'	73 deg 14.289'	5/8/02	6/20/02	6	6	100%	Successful
J-KM04	42 deg 25.255	73 deg 13.905	5/8/02	6/16/02	5	4	80%	Successful
K-WP	42 deg 20.469'	73 deg 14.496'	5/23/02	6/11/02	3	3	100%	Successful
M2-WP	42 deg 20.630'	73 deg 14.390'	6/11/02	N/A	2	0	0%	Depredated
N-KM16	42 deg 22.061'	73 deg 14.355'	6/10/02	N/A	0	0	0%	Depredated
O-WP	42 deg 20.339'	73 deg 14.524'	6/11/01	6/10/02	4	4	100%	Successful
P-WP	42 deg 20.609'	73 deg 14.366'	6/11/02	7/3/02	5	2	40%	Successful

Notes:

HSI = Habitat Suitability Index

deg = degrees

Successful = fledged at least one young

N/A = not available

Table 2. Results of Habitat Suitability Index Model

Sampling Segment	Subscore for Water Component	Subscore for Cover Component	Subscore for Breeding Component	Overall Score
BW_01	0.06	1	0.8	0.06
BW_02	0.2	1	0.8	0.2
BW_03_KM17	0.03	1	0.7	0.03
BW04	0.05	1	0.8	0.05
BW05	0.4	1	0.9	0.4
KM_17	0.4	1	0.8	0.4
KM01	0.4	1	1	0.4
KM02	0.4	1	1	0.4
KM03	0.4	1	1	0.4
KM04	0.5	1	1	0.5
KM05	0.4	1	1	0.4
KM06	0.4	1	1	0.4
KM07	0.4	1	1	0.4
KM08	0.4	1	1	0.4
KM09	0.4	1	1	0.4
KM10	0.4	1	1	0.4
KM11	0.4	1	1	0.4
KM12	0.4	1	1	0.4
KM13	0.4	1	0.8	0.4
KM14	0.4	1	1	0.4
KM15	0.4	1	1	0.4
KM16	0.4	1	1	0.4
KM17_BW03	0.05	1	0.7	0.05
WP01	0.2	1	1	0.2
WP02	0.3	1	0.8	0.3
WP03	0.4	1	0.9	0.4

Table 3. Evaluation of Suitable Bank Habitat[a]

Bank ID	Segment ID	Bank Height (m)	Bank Occupied?	Suitable Bank?
103	WP01-03	6.1	No	Yes
96	WP01-03	23	No	Yes
121	WP01-03	9.9	No	Yes
124	WP01-03	16	No	Yes
1	KM01	0.30	No	No
34	KM05	1.4	No	No
41	KM07	2.7	No	Yes
72	KM11	1.5	No	Yes
79	KM11	1.4	No	No
105	WP01-03	8.5	Yes	Yes
114	WP01-03	5.5	Yes	No
123	WP01-03	20	Yes	Yes
95	WP01-03	25	Yes	Yes
129	WP01-03	6.4	Yes	No
87	KM16	4.6	Yes	Yes
23	KM04	7.5	Yes	No
7	KM01	2.1	Yes	Yes
39	KM07	3.4	Yes	Yes
43	KM08	2.3	Yes	Yes

Notes:

a. Suitability of banks determined per Prose (1985)

Number of burrows in nonsuitable banks = 3 out of 6 or 50%

Number of burrows in suitable banks = 7 out of 13 or 54%

Table 4. Estimated PCB Doses for Belted Kingfishers Breeding Within Housatonic River Study Area[a]

Burrow	PCBs in Crayfish and Fish[b] (ppm, wet weight)			n	Estimated Adult Dose[c,d] (mg/kg-day)			Estimated Fledgling Dose[c,e] (mg/kg-day)		
E-KM01	42	±	2.2	13	21	±	1.1	57	±	3.0
G-KM07	21	±	2.8	25	10	±	1.4	29	±	3.8
H-KM08	21	±	2.8	25	10	±	1.4	29	±	3.8
J-KM04	32	±	3.4	21	16	±	1.7	44	±	4.6
K-WP	24	±	1.1	84	12	±	0.53	33	±	1.5
M2-WP	24	±	1.1	84	12	±	0.53	33	±	1.5
N-KM16	15	±	2.0	21	7.4	±	0.98	20	±	2.7
O-WP	24	±	1.1	84	12	±	0.53	33	±	1.5
P-WP	24	±	1.1	84	12	±	0.53	33	±	1.5

Notes:

a. Values shown are mean ± SE.

b. Based on measured concentrations in crayfish and 4-14 cm length fish collected from within 1200 m of burrow

c. Intake = prey concentration x food ingestion rate

d. Adult prey ingestion rate = 0.50 g/g-day (Alexander 1977)

e. Nestling prey ingestion rate = 1.375 (White 1936)

Table 5. Summary of Statistical Analyses with Depredated Nests Included

Hypothesis tested	Test	MS	MSE	degrees of freedom[a]	F	R^2	t	p	Conclusion
Effect of Estimated PCB dose on:									
Outcome	t-test; S < Dp			7			-1.8	0.95	No significant relationship
Number surviving to 26 days	Linear Regression	5.9	4.1	8	4.6	0.40		0.069	No significant relationship
Percent surviving to 26 days	Linear Regression	0.22	0.17	8	3.7	0.35		0.10	No significant relationship
Effect of HSI score on:									
Outcome	t-test; S > Dp			7			-0.071	0.47	No significant relationship
Number surviving to 26 days	Linear Regression	5.9	6.3	8	0.57	0.070		0.48	No significant relationship
Percent surviving to 26 days	Linear Regression	0.22	0.26	8	0.046	0.010		0.84	No significant relationship
Occupation of banks	t-test; Occupied > Unoccupied			28			-0.71	0.24	No significant relationship
Effect of hatch date on:									
Outcome	t-test; S < Dp			5			0.93	0.18	No significant relationship
Number surviving to 26 days	Linear Regression	4.6	3.7	6	2.5	0.34		0.17	No significant relationship
Percent surviving to 26 days	Linear Regression	0.16	0.072	6	8.1	0.62		0.036	Significant relationship of decreased survival with later fledge date
Effect of nest density on:									
Outcome	t-test; S > Dp			7			0.34	0.37	No significant relationship
Number surviving to 26 days	Linear Regression	5.9	6.5	8	0.33	0.040		0.58	No significant relationship
Percent surviving to 26 days	Linear Regression	0.22	0.26	8	0.0050	0.00070		0.94	No significant relationship

Notes:

a. The degrees of freedom is equal to n-2 for t-tests and n-1 for regression analysis. The degrees of freedom is lower for the hatch date because hatch date is not applicable for nest which are depredated before hatching

PCB = polychlorinated biphenyl

HSI = Habitat Suitability Index

Dp = Depredated

S = Successful

MS = total mean squared variance

MSE = mean squared variance error

Table 6. Summary of Multivariate Statistical Analyses

Response Variable	Model Parameters[a]	Cumulative R^2	R^2 change	t-value H0:B(I)=0	p
Percent Survived to 26 Days					
	Intercept			0.22	0.84
	Hatch Date	0.62	0.62	-1.4	0.30
	Nest Density	0.63	0.0082	0.13	0.91
	Estimated Adult PCB Dose	0.63	0.0043	0.079	0.95
	H S I	0.63	0.00030	0.039	0.97
	Combined Model	F:0.8532	p:0.60		
Number Survived to 26 Days					
	Intercept			0.50	0.67
	Hatch Date	0.34	0.34	-0.65	0.58
	Nest Density	0.42	0.084	-0.46	0.69
	Estimated Adult PCB Dose	0.44	0.014	0.41	0.72
	H S I	0.47	0.031	-0.34	0.76
	Combined Model	F:0.437	p:0.78		

Notes:

a. Model parameters are sequentaily added to the model. The order of this addition is based on the fraction of the R^2 in the response variable that can be accounted for by this model parameter.

Cumulative R^2 = percent of total variability accounted for when this variable is sequentially added to the model

Change in R^2 = how much of total R^2 can be accounted for based on the addition of this variable to the model

PCB = polychlorinated biphenyl

HSI = habitat suitability index

Table 7. Summary of Linear Regression Analyses With Depredated Nests Excluded[a]

Hypothesis tested	MS	MSE	degrees of freedom[b]	F	R^2	p	Conclusion
Effect of Estimated PCB dose on:							
Number surviving to 26 days	2.6	2.8	5	0.60	0.13	0.48	No significant relationship
Percent surviving to 26 days	0.059	0.070	5	0.20	0.048	0.68	No significant relationship
Effect of HSI on:							
Number surviving to 26 days	2.6	2.3	5	1.5	0.28	0.28	No significant relationship
Percent surviving to 26 days	0.059	0.072	5	0.096	0.020	0.77	No significant relationship
Effect of hatch date on:							
Number surviving to 26 days	2.6	2.5	5	1.2	0.23	0.34	No significant relationship
Percent surviving to 26 days	0.059	0.013	5	18	0.82	0.013	Significant relationship of decreased survival with later fledge date
Effect of nest density on:							
Number surviving to 26 days	2.6	1.4	5	5.0	0.55	0.090	No significant relationship
Percent surviving to 26 days	0.059	0.068	5	0.31	0.070	0.61	No significant relationship

Notes:

a. Outcome is not included in this analysis because all outcomes were successful when depredated nests are excluded.

b. The degrees of freedom is equal to sample size (n) - 1.

PCB = polychlorinated biphenyl

HSI = Habitat Suitability Index

Dp = Depredated

S = Successful

MS = the total mean squared variance

MSE = the error mean squared variance

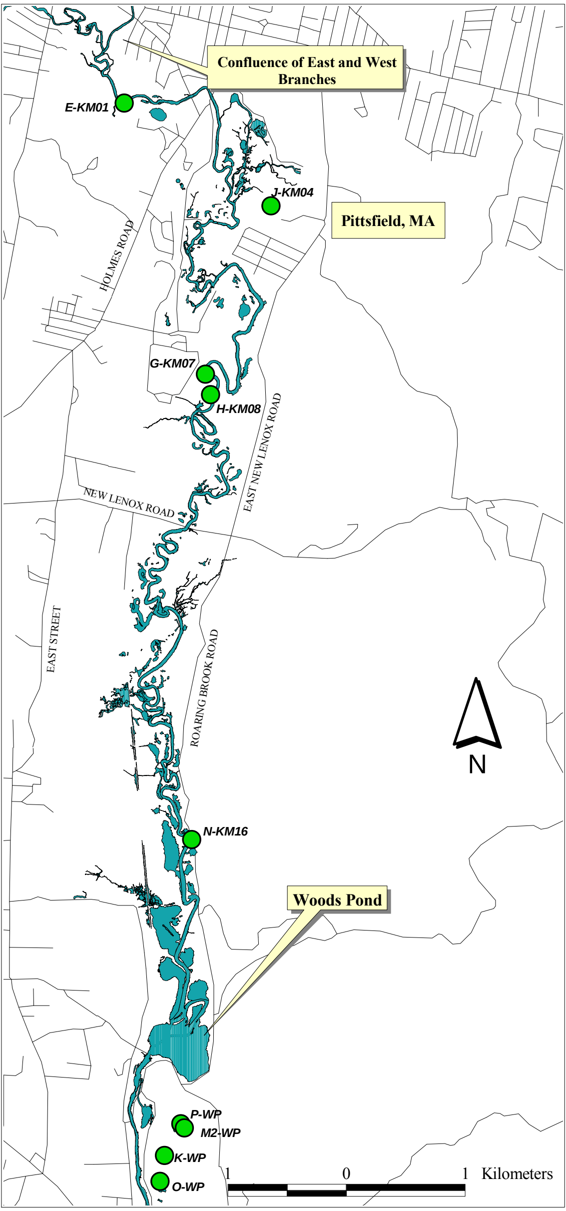
Table 8. Comparison of Housatonic Study Area Survival to 26 Days with Brooks and Davis (1987) Data

	Including Depredated Nests			Excluding Depredated Nests		
	Mean	n	se	Mean	n	se
Housatonic[a]						
Number to Survive to 26 Days	2.8	9	0.81	4.2	6	0.65
Survival to 26 Days (%)	58%	9	0.16	87%	6	0.099
Ohio[b]						
Number Fledged	5.3	6	0.88	5.3	6	0.88
Fledging Success (%)	79%	6	0.13	79%	6	0.13
Pennsylvania[b]						
Number Fledged	4.5	8	0.68	5.1	7	0.26
Fledging Success (%)	80%	8	0.13	91%	7	0.062

Notes:

a. Current study

b. Data including depredated nests from Brooks and Davis (1987); Data excluding depredated nests provided as personal communication (Robert Brooks, October 7, 2002).



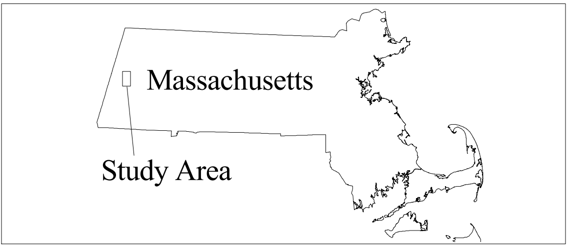


Figure 1. Kingfisher Burrow Locations (2002) in the Housatonic River Study Area

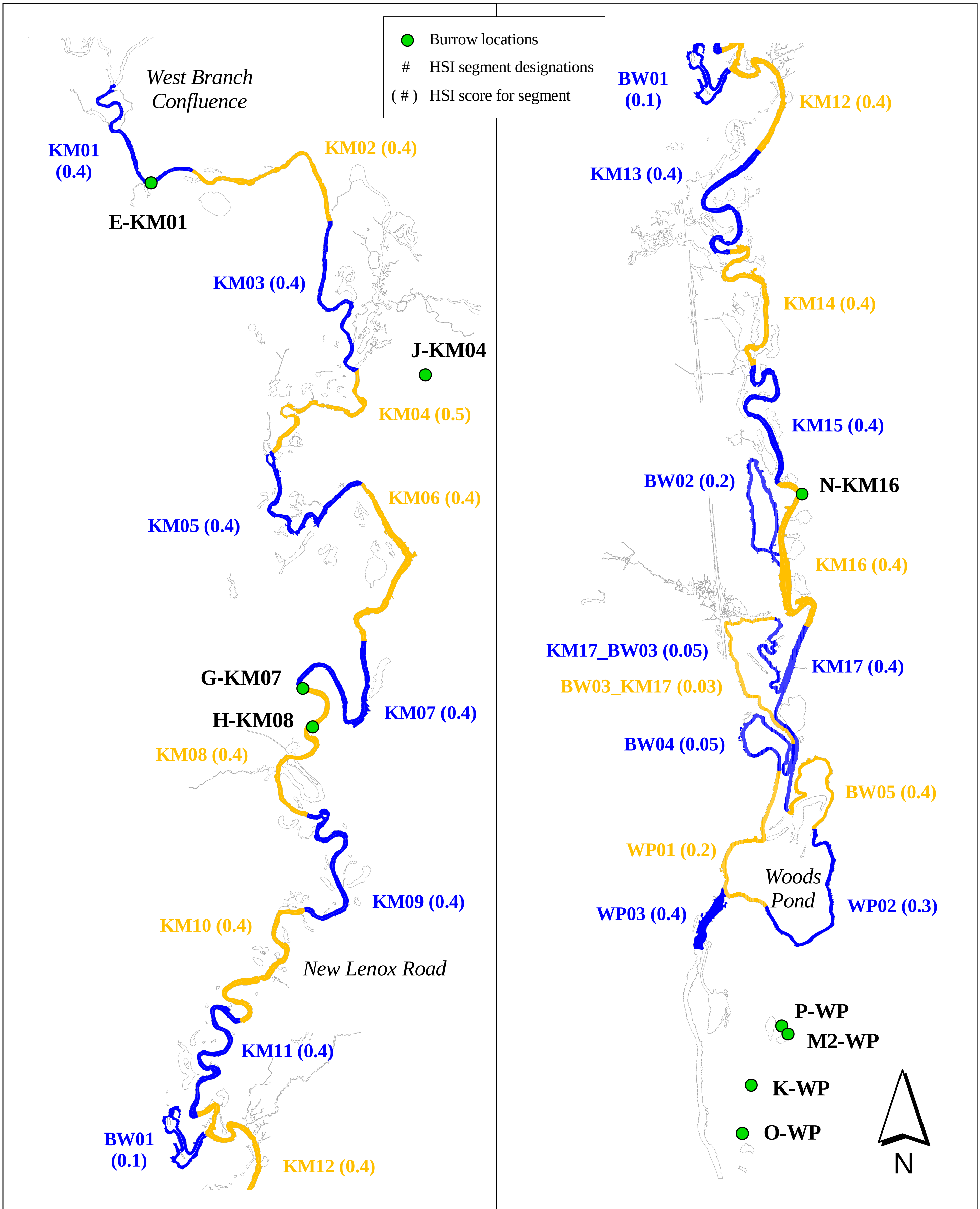


Figure 2. Locations of 1-km River Segments Used to Conduct Habitat Suitability Index Model

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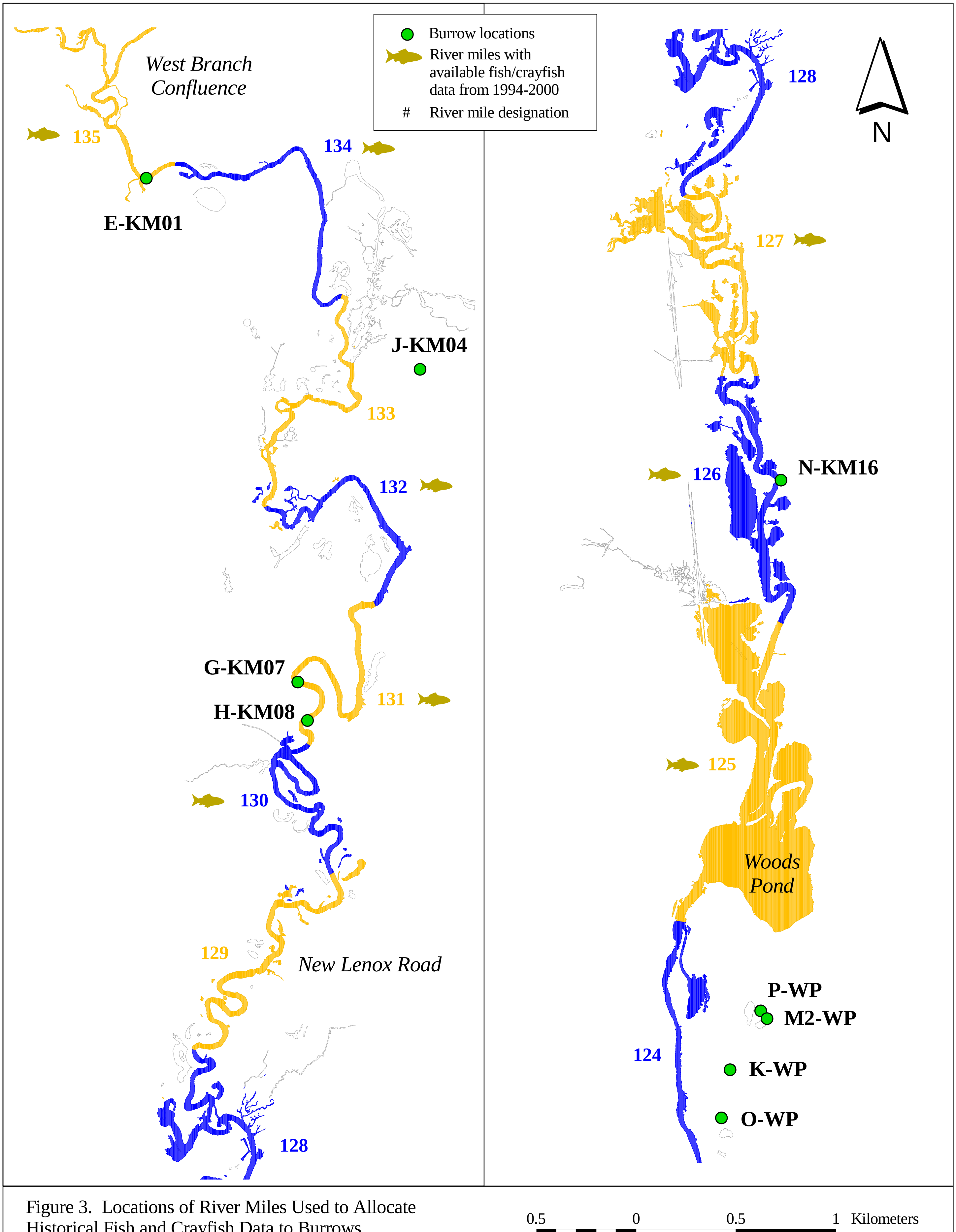

Figure 3. Locations of River Miles Used to Allocate Historical Fish and Crayfish Data to Burrows

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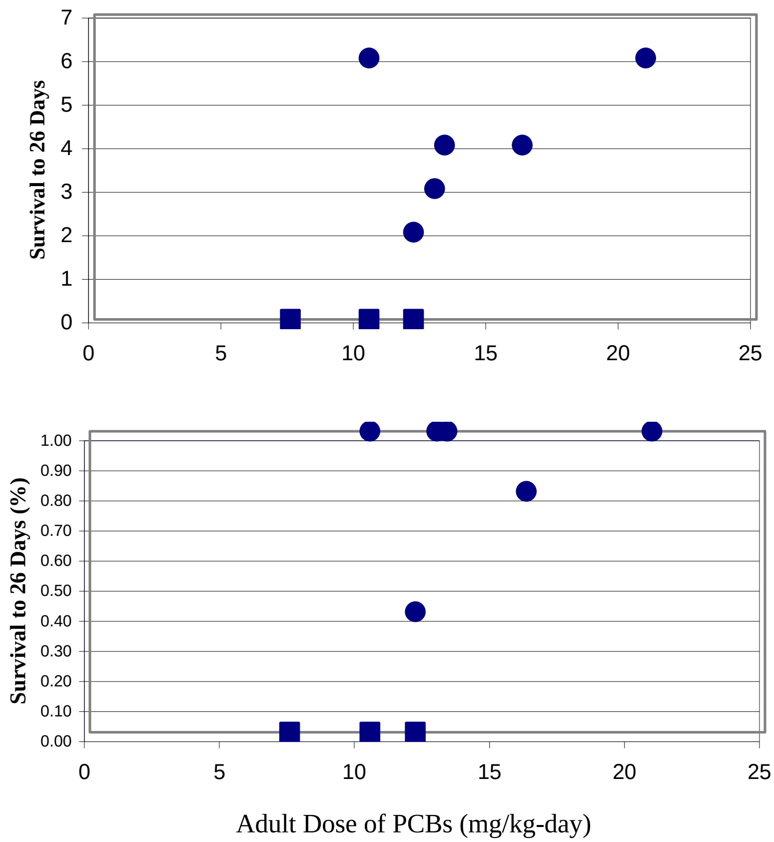


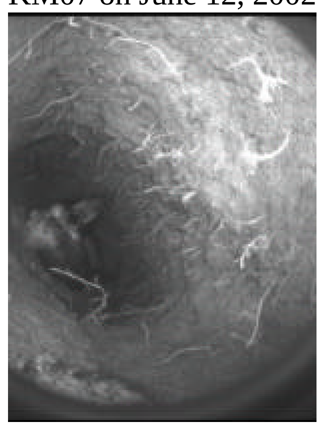
Figure 4. Relationships Between Estimated Adult Doses of PCBs and Survival to 26 Days. Successful and depredated nests are plotted with circles and squares, respectively.

Photograph 1. Peeper Probe in Use Monitoring Kingfisher Nest

Photograph 2. Incubating Female at E-KM01 on May 23, 2002

Photograph 3. Six 17-day Old Nestlings at E-KM01 on June 27, 2002

Photograph 4. Incubating Adult at G-KM07 on June 12, 2002



Photograph 5. At Least Four 1-day Old Nestlings at G-KM07 on June 27, 2002

Photograph 6. Depredated Burrow G-KM07 on July 7, 2002

Photograph 7. Single Egg in H-KM08 on May 23, 2002 at Start of Egg-Laying

Photograph 8. Six 5- or 6-day Old Nestlings at H-KM08 on June 27, 2002

Photograph 9. Six 15- or 16-day Old Nestlings at H-KM08 on July 7, 2002

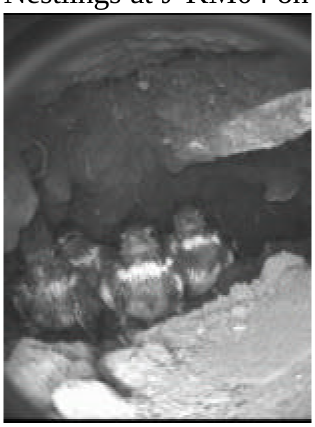
Photograph 10. Juvenile Kingfisher from H-KM08 Presumably Killed by a Bird of Prey on July 17, 2002

Photograph 11. Single Egg in J-KM04 on May 23, 2002 at Start of Egg-Laying

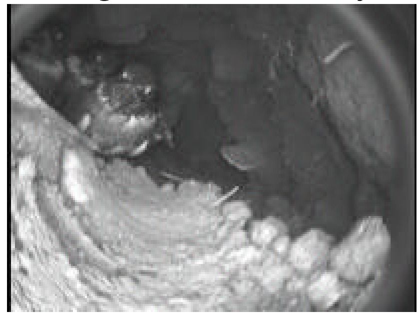
Photograph 12. Adult Kingfisher and At Least Four Eggs at J-KM04 on June 13, 2002

Photograph 13. Five 10-day Old Nestlings at J-KM04 on June 27, 2002

Photograph 14. Four 20-day Old Nestlings at J-KM04 on July 7, 2002



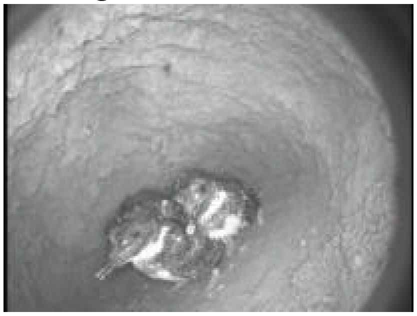
Photograph 15. Four 26-day Old Nestlings at J-KM04 on July 13, 2002



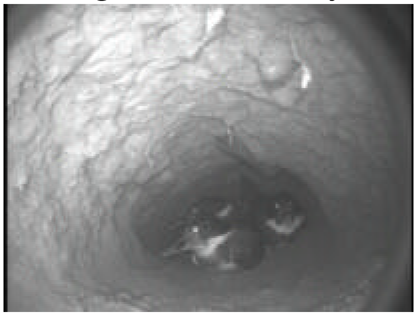
Photograph 16. Incubating Male at K-WP on May 24, 2002

Photograph 17. Adult, At Least One Egg and At Least Three 1-day Old Nestlings at K-WP on June 12, 2002

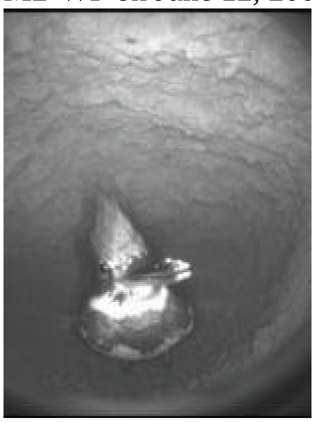
Photograph 18. Three 16-day Old Nestlings at K-WP on June 27, 2002



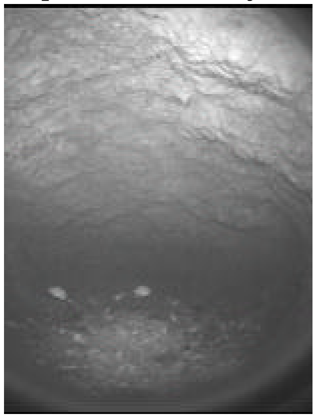
Photograph 19. Three 26-day Old Nestlings at K-WP on July 7, 2002



Photograph 20. One Adult on Nest at M2-WP on June 12, 2002



Photograph 21. M2-WP Following Depredation on July 16, 2002



Photograph 22. N-KM16 Following Depredation on June 27, 2002

Photograph 23. Adult Kingfisher from N-KM16 on June 27, 2002, Presumably Killed by a Mustelid

Photograph 24. Four 16-day Old Nestlings at O-WP on June 27, 2002

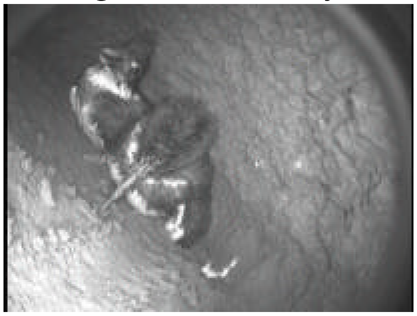
Photograph 25. Four 26–day Old Nestlings at O-WP on July 7, 2002

Photograph 26. Adult Incubating at P-WP on June 27, 2002

Photograph 27. At Least Four Sleeping 4-day Old Nestlings at P-WP on July 7, 2002

Photograph 28. Five 13-day Old Nestlings at P-WP on July 16, 2002

Photograph 29. Two 23-day Old Nestlings at P-WP on July 26, 2002



Appendix A

Fish and Crayfish Data Used to Estimate Doses of PCBs to Kingfishers

Appendix A. Fish and Crayfish Data Used to Estimate Dose of PCBs to Kingfishers

Data Source	Sample Identity	Location	River Mile	Burrows Located Within 1200 m[a]	Date Collected	Species	Sample Type	Number Individ-uals[b]	Average Length (cm)	Concentra-tion of Total PCBs (ppm, wet weight)	Analytical Method
USEPA	H3-TW03FFC1-0-8C19	Reach 5 Confluence to Woods Pond	134	E, J	10/19/98	Fallfish	COMP	6	8.78	44.7	Congener
USEPA	H3-TW03FFC1-0-8C02	Reach 5 Confluence to Woods Pond	134	E, J	10/03/98	Fallfish	COMP	5	8.46	45.4	Congener
USEPA	H3-TW03FFC2-0-8C19	Reach 5 Confluence to Woods Pond	134	E, J	10/19/98	Fallfish	COMP	5	11.3	47.8	Congener
USEPA	H3-TW03FFC2-0-8C02	Reach 5 Confluence to Woods Pond	134	E, J	10/03/98	Fallfish	COMP	5	8.6	42.4	Congener
USEPA	H3-TW03LBC1-0-8C02	Reach 5 Confluence to Woods Pond	134	E, J	10/03/98	Largemouth Bass	COMP	5	7.48	51.2	Congener
USEPA	H3-TW03LBC2-0-8C02	Reach 5 Confluence to Woods Pond	134	E, J	10/03/98	Largemouth Bass	COMP	5	7.96	50.7	Congener
USEPA	H3-TW03YPC1-0-8C20	Reach 5 Confluence to Woods Pond	134	E, J	10/20/98	Yellow Perch	COMP	5	8.66	29.7	Congener
USEPA	H3-TW03YPC2-0-8C20	Reach 5 Confluence to Woods Pond	134	E, J	10/20/98	Yellow Perch	COMP	5	9.74	38.5	Congener
USEPA	H3-TW03YPC3-0-8C20	Reach 5 Confluence to Woods Pond	134	E, J	10/20/98	Yellow Perch	COMP	5	8.7	40.6	Congener
USEPA	H3-TW03YPC4-0-8C20	Reach 5 Confluence to Woods Pond	134	E, J	10/20/98	Yellow Perch	COMP	5	9.4	24.1	Congener
USEPA	H3-TW03YPC5-0-8C20	Reach 5 Confluence to Woods Pond	134	E, J	10/20/98	Yellow Perch	COMP	5	13.36	46.9	Congener
GE	9924	West Branch Confluence (WWTP) - H3	135	E	11/12/98	Pumpkinseed	COMP	6	7.63	41.6	Congener
GE	9925	West Branch Confluence (WWTP) - H3	135	E	11/12/98	Pumpkinseed	COMP	5	8.68	37.6	Congener
USEPA	H3-TW06WS02-0-0G25	Reach 5 Confluence to Woods Pond	131	G, H	08/25/00	White Sucker	INDIV		12.2	44.5	Congener
USEPA	H3-TW07GSC1-0-8S30	Reach 5 Confluence to Woods Pond	130	G, H	09/30/98	Golden Shiner	COMP	5	10.28	27.6	Congener
USEPA	H3-TW07LBC1-0-8S30	Reach 5 Confluence to Woods Pond	130	G, H	09/30/98	Largemouth Bass	COMP	5	7.3	37.4	Congener
USEPA	H3-TW07PSC1-0-8S29	Reach 5 Confluence to Woods Pond	130	G, H	09/30/98	Pumpkinseed	COMP	5	9.5	29.9	Congener
USEPA	H3-TW07YPC1-0-8S29	Reach 5 Confluence to Woods Pond	130	G, H	09/30/98	Yellow Perch	COMP	5	9.72	39.8	Congener
USEPA	H3-TW10YPC1-0-8S30	Reach 5 Confluence to Woods Pond	127	N	09/30/98	Yellow Perch	COMP	5	8.58	16.5	Congener
USEPA	H3-TW11GSC1-0-8S30	Reach 5 Confluence to Woods Pond	126	N	10/01/98	Golden Shiner	COMP	5	12.48	8.2	Congener
USEPA	H3-TW11GSC2-0-8S30	Reach 5 Confluence to Woods Pond	126	N	10/01/98	Golden Shiner	COMP	5	10.76	2.6	Congener
USEPA	H3-TW11LB26-0-8S30	Reach 5 Confluence to Woods Pond	126	N	10/01/98	Largemouth Bass	INDIV		14	25.9	Congener
USEPA	H3-TW11LBC1-0-8S30	Reach 5 Confluence to Woods Pond	126	N	10/01/98	Largemouth Bass	COMP	5	10.96	22.4	Congener
USEPA	H3-TW11LBC2-0-8S30	Reach 5 Confluence to Woods Pond	126	N	10/01/98	Largemouth Bass	COMP	5	9.48	24.2	Congener
USEPA	H3-TW11PSC1-0-8S30	Reach 5 Confluence to Woods Pond	126	N	10/01/98	Pumpkinseed	COMP	5	10.9	27.5	Congener
USEPA	H3-TW11PSC2-0-8S30	Reach 5 Confluence to Woods Pond	126	N	10/01/98	Pumpkinseed	COMP	5	10.12	25.6	Congener
USEPA	H3-TW11PSC3-0-8S30	Reach 5 Confluence to Woods Pond	126	N	10/01/98	Pumpkinseed	COMP	5	9.02	26.4	Congener
USEPA	H3-TW11PSC4-0-8S30	Reach 5 Confluence to Woods Pond	126	N	10/01/98	Pumpkinseed	COMP	5	8.16	26.5	Congener
USEPA	H3-TW11YPC1-0-8S30	Reach 5 Confluence to Woods Pond	126	N	10/01/98	Yellow Perch	COMP	5	10.1	23.1	Congener
USEPA	H4-TWWPGSC1-0-8C01	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Golden Shiner	COMP	5	13.54	26.3	Congener
USEPA	H4-TWWPGSC2-0-8C01	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Golden Shiner	COMP	5	9.02	22.5	Congener
USEPA	H4-TWWPGSC3-0-8C01	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Golden Shiner	COMP	6	7.17	21.1	Congener
USEPA	H4-TWWPGSC4-0-8C01	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Golden Shiner	COMP	6	7.4	19.8	Congener

Appendix A. Fish and Crayfish Data Used to Estimate Dose of PCBs to Kingfishers

Data Source	Sample Identity	Location	River Mile	Burrows Located Within 1200 m[a]	Date Collected	Species	Sample Type	Number Individuals[b]	Average Length (cm)	Concentration of Total PCBs (ppm, wet weight)	Analytical Method
USEPA	H4-TWWPGSC5-0-8C01	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Golden Shiner	COMP	10	6.61	22.4	Congener
USEPA	H4-TWWPLB18-0-8C01	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Largemouth Bass	INDIV		12	47.9	Congener
USEPA	H4-TWWPLB19-0-8C01	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Largemouth Bass	INDIV		13.5	22.2	Congener
USEPA	H4-TWWPLB20-0-8C01	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Largemouth Bass	INDIV		13	30.6	Congener
USEPA	H4-TWWPLBC1-0-8S30	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Largemouth Bass	COMP	5	10.24	12.9	Congener
USEPA	H4-TWWPLBC2-0-8S30	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Largemouth Bass	COMP	5	11.08	10.7	Congener
USEPA	H4-TWWPLBC3-0-8S30	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Largemouth Bass	COMP	5	8.06	9.0	Congener
USEPA	H4-TWWPLBC4-0-8C01	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Largemouth Bass	COMP	5	9.3	28.1	Congener
USEPA	H4-TWWPLBC5-0-8C01	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Largemouth Bass	COMP	5	7.9	22.3	Congener
USEPA	H4-TWWPPSC1-0-8S30	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Pumpkinseed	COMP	5	9.82	8.8	Congener
USEPA	H4-TWWPPSC1-0-8C21	Reach 6 - Woods Pond	125	K, O, M2, P	10/21/98	Pumpkinseed	COMP	5	8.9	27.9	Congener
USEPA	H4-TWWPPSC2-0-8C21	Reach 6 - Woods Pond	125	K, O, M2, P	10/21/98	Pumpkinseed	COMP	5	9.58	35.1	Congener
USEPA	H4-TWWPPSC2-0-8C01	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Pumpkinseed	COMP	5	10.3	27.9	Congener
USEPA	H4-TWWPPSC3-0-8C21	Reach 6 - Woods Pond	125	K, O, M2, P	10/21/98	Pumpkinseed	COMP	5	10.12	29.9	Congener
USEPA	H4-TWWPYPC1-0-8C01	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Yellow Perch	COMP	5	9.8	32.6	Congener
USEPA	H4-TWWPYPC2-0-8C01	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Yellow Perch	COMP	5	10.72	27.4	Congener
USEPA	H4-TWWPYPC3-0-8C01	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Yellow Perch	COMP	5	9.5	27.5	Congener
USEPA	H4-TWWPYPC4-0-8C01	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Yellow Perch	COMP	5	9.74	31.4	Congener
USEPA	H4-TWWPYPC5-0-8C01	Reach 6 - Woods Pond	125	K, O, M2, P	10/01/98	Yellow Perch	COMP	5	9.86	31.0	Congener
USEPA	H3-TD05OVWB-0-M001	Reach 5 Confluence to Woods Pond	132	G, H, J	09/08/99	Crayfish	INDIV		8.9	20.1	Congener
USEPA	H3-TD05OVWB-0-F002	Reach 5 Confluence to Woods Pond	132	G, H, J	09/09/99	Crayfish	INDIV		10.3	40.4	Congener
USEPA	H3-TD05OVWB-0-F005	Reach 5 Confluence to Woods Pond	132	G, H, J	09/14/99	Crayfish	INDIV		9.7	25.8	Congener
USEPA	H3-TD05OVWB-0-M007	Reach 5 Confluence to Woods Pond	132	G, H, J	09/15/99	Crayfish	INDIV		10.5	21.8	Congener
USEPA	H3-TD05OVWB-0-M008	Reach 5 Confluence to Woods Pond	132	G, H, J	09/15/99	Crayfish	INDIV		9	13.1	Congener
USEPA	H3-TD05OVWB-0-M014	Reach 5 Confluence to Woods Pond	132	G, H, J	09/24/99	Crayfish	INDIV		10.3	15.9	Congener
USEPA	H3-TD05OVWB-0-M020	Reach 5 Confluence to Woods Pond	132	G, H, J	10/05/99	Crayfish	INDIV		8.7	8.1	Congener
USEPA	H3-TD05OVWB-0-M021	Reach 5 Confluence to Woods Pond	132	G, H, J	10/05/99	Crayfish	INDIV		8.7	9.4	Congener
USEPA	H3-TD05OVWB-0-M022	Reach 5 Confluence to Woods Pond	132	G, H, J	10/05/99	Crayfish	INDIV		10	52.1	Congener
USEPA	H3-TD05OVWB-0-M023	Reach 5 Confluence to Woods Pond	132	G, H, J	10/07/99	Crayfish	INDIV		10.4	9.9	Congener
USEPA	H3-TD07OVWB-0-M001	Reach 5 Confluence to Woods Pond	130	G, H	09/09/99	Crayfish	INDIV		9.6	6.6	Congener
USEPA	H3-TD07OVWB-0-M003	Reach 5 Confluence to Woods Pond	130	G, H	09/15/99	Crayfish	INDIV		9	4.3	Congener
USEPA	H3-TD07OVWB-0-M004	Reach 5 Confluence to Woods Pond	130	G, H	09/22/99	Crayfish	INDIV		9	9.7	Congener
USEPA	H3-TD07OVWB-0-M006	Reach 5 Confluence to Woods Pond	130	G, H	09/23/99	Crayfish	INDIV		9	14.8	Congener
USEPA	H3-TD07OVWB-0-M007	Reach 5 Confluence to Woods Pond	130	G, H	09/23/99	Crayfish	INDIV		8.4	20.4	Congener

Appendix A. Fish and Crayfish Data Used to Estimate Dose of PCBs to Kingfishers

Data Source	Sample Identity	Location	River Mile	Burrows Located Within 1200 m[a]	Date Collected	Species	Sample Type	Number Individ-uals[b]	Average Length (cm)	Concentra-tion of Total PCBs (ppm, wet weight)	Analytical Method
USEPA	H3-TD07OVWB-0-M008	Reach 5 Confluence to Woods Pond	130	G, H	09/23/99	Crayfish	INDIV		9	7.4	Congener
USEPA	H3-TD07OVWB-0-M011	Reach 5 Confluence to Woods Pond	130	G, H	09/24/99	Crayfish	INDIV		9	13.7	Congener
USEPA	H3-TD07OVWB-0-M014	Reach 5 Confluence to Woods Pond	130	G, H	09/29/99	Crayfish	INDIV		8.7	6.8	Congener
USEPA	H3-TD07OVWB-0-F002	Reach 5 Confluence to Woods Pond	130	G, H	09/09/99	Crayfish	INDIV		8.7	31.6	Congener
USEPA	H3-TD07OVWB-0-M021	Reach 5 Confluence to Woods Pond	130	G, H	10/06/99	Crayfish	INDIV		8.7	7.5	Congener
USEPA	H3-TD11OVWB-0-M001	Reach 5 Confluence to Woods Pond	126	N	09/14/99	Crayfish	INDIV		9.8	8.6	Congener
USEPA	H3-TD11OVWB-0-M003	Reach 5 Confluence to Woods Pond	126	N	09/22/99	Crayfish	INDIV		8.9	6.8	Congener
USEPA	H3-TD11OVWB-0-F004	Reach 5 Confluence to Woods Pond	126	N	09/23/99	Crayfish	INDIV		9.1	7.2	Congener
USEPA	H3-TD11OVWB-0-M005	Reach 5 Confluence to Woods Pond	126	N	09/27/99	Crayfish	INDIV		8.7	8.2	Congener
USEPA	H3-TD11OVWB-0-F013	Reach 5 Confluence to Woods Pond	126	N	09/28/99	Crayfish	INDIV		8.8	7.5	Congener
USEPA	H3-TD11OVWB-0-M014	Reach 5 Confluence to Woods Pond	126	N	09/29/99	Crayfish	INDIV		7.4	2.6	Congener
USEPA	H3-TD11OVWB-0-F023	Reach 5 Confluence to Woods Pond	126	N	09/30/99	Crayfish	INDIV		7.1	8.1	Congener
USEPA	H3-TD11OVWB-0-M024	Reach 5 Confluence to Woods Pond	126	N	10/01/99	Crayfish	INDIV		9.3	5.7	Congener
USEPA	H3-TD11OVWB-0-F026	Reach 5 Confluence to Woods Pond	126	N	10/14/99	Crayfish	INDIV		9.7	12.7	Congener
USEPA	H3-TD11OVWB-0-F027	Reach 5 Confluence to Woods Pond	126	N	10/14/99	Crayfish	INDIV		9.1	14.7	Congener
USEPA	H3-TD12OVWB-0-F007	Reach 5 Confluence to Woods Pond	125	K, O, M2, P	09/07/99	Crayfish	INDIV		10.1	6.7	Congener
USEPA	H3-TD12OVWB-0-F009	Reach 5 Confluence to Woods Pond	125	K, O, M2, P	09/23/99	Crayfish	INDIV		8.2	15.8	Congener
USEPA	H3-TD12OVWB-0-M010	Reach 5 Confluence to Woods Pond	125	K, O, M2, P	09/24/99	Crayfish	INDIV		8.9	4.6	Congener
USEPA	H3-TD12OVWB-0-M011	Reach 5 Confluence to Woods Pond	125	K, O, M2, P	09/28/99	Crayfish	INDIV		10.4	6.6	Congener
USEPA	H3-TD12OVWB-0-M013	Reach 5 Confluence to Woods Pond	125	K, O, M2, P	09/30/99	Crayfish	INDIV		9.2	8.5	Congener
USEPA	H3-TD12OVWB-0-M014	Reach 5 Confluence to Woods Pond	125	K, O, M2, P	10/05/99	Crayfish	INDIV		6.4	4.0	Congener
USEPA	H3-TD12OVWB-0-M015	Reach 5 Confluence to Woods Pond	125	K, O, M2, P	10/05/99	Crayfish	INDIV		10	6.0	Congener
USEPA	H3-TD12OVWB-0-F006	Reach 5 Confluence to Woods Pond	125	K, O, M2, P	09/07/99	Crayfish	INDIV		7.7	4.6	Congener
USEPA	H3-TD12OVWB-0-M017	Reach 5 Confluence to Woods Pond	125	K, O, M2, P	10/08/99	Crayfish	INDIV		9.2	5.7	Congener
USEPA	H3-TD12OVWB-0-M018	Reach 5 Confluence to Woods Pond	125	K, O, M2, P	10/08/99	Crayfish	INDIV		8	5.5	Congener
GE	4399	Woods Pond	125	K, O, M2, P	10/12/94	Largemouth bass	COMP	10	7.19	19.0	Aroclor
GE	4400	Woods Pond	125	K, O, M2, P	10/12/94	Largemouth bass	COMP	10	7.07	17.0	Aroclor
GE	4401	Woods Pond	125	K, O, M2, P	10/12/94	Largemouth bass	COMP	10	7.62	19.0	Aroclor
GE	4402	Woods Pond	125	K, O, M2, P	10/12/94	Largemouth bass	COMP	10	7.36	18.0	Aroclor
GE	4403	Woods Pond	125	K, O, M2, P	10/12/94	Largemouth bass	COMP	10	7.33	18.0	Aroclor
GE	4404	Woods Pond	125	K, O, M2, P	10/12/94	Largemouth bass	COMP	10	6.91	37.0	Aroclor
GE	4405	Woods Pond	125	K, O, M2, P	10/12/94	Yellow perch	COMP	5	8.54	36.0	Aroclor
GE	4406	Woods Pond	125	K, O, M2, P	10/12/94	Yellow perch	COMP	5	8.74	32.0	Aroclor
GE	4407	Woods Pond	125	K, O, M2, P	10/12/94	Yellow perch	COMP	5	8.78	38.0	Aroclor

Appendix A. Fish and Crayfish Data Used to Estimate Dose of PCBs to Kingfishers

Data Source	Sample Identity	Location	River Mile	Burrows Located Within 1200 m[a]	Date Collected	Species	Sample Type	Number Individuals[b]	Average Length (cm)	Concentration of Total PCBs (ppm, wet weight)	Analytical Method
GE	4408	Woods Pond	125	K, O, M2, P	10/12/94	Yellow perch	COMP	5	8.42	58.0	Aroclor
GE	4409	Woods Pond	125	K, O, M2, P	10/12/94	Yellow perch	COMP	5	8.66	32.0	Aroclor
GE	4410	Woods Pond	125	K, O, M2, P	10/12/94	Yellow perch	COMP	5	8.42	32.0	Aroclor
GE	4411	Woods Pond	125	K, O, M2, P	10/12/94	Yellow perch	COMP	5	8.12	35.0	Aroclor
GE	5267	Woods Pond	125	K, O, M2, P	10/14/96	Bluegill	COMP	12	4.042	19.0	Aroclor
GE	5268	Woods Pond	125	K, O, M2, P	10/14/96	Bluegill	COMP	12	4.6	20.0	Aroclor
GE	5269	Woods Pond	125	K, O, M2, P	10/14/96	Bluegill	COMP	12	4.067	21.0	Aroclor
GE	5274	Woods Pond	125	K, O, M2, P	10/14/96	Largemouth bass	COMP	10	7.26	24.0	Aroclor
GE	5275	Woods Pond	125	K, O, M2, P	10/14/96	Largemouth bass	COMP	10	7.37	23.0	Aroclor
GE	5276	Woods Pond	125	K, O, M2, P	10/14/96	Largemouth bass	COMP	10	7.33	21.0	Aroclor
GE	5277	Woods Pond	125	K, O, M2, P	10/14/96	Largemouth bass	COMP	10	7.08	22.0	Aroclor
GE	5278	Woods Pond	125	K, O, M2, P	10/14/96	Largemouth bass	COMP	10	7.24	25.0	Aroclor
GE	5279	Woods Pond	125	K, O, M2, P	10/14/96	Largemouth bass	COMP	10	7.37	19.0	Aroclor
GE	5280	Woods Pond	125	K, O, M2, P	10/14/96	Largemouth bass	COMP	10	7.46	21.0	Aroclor
GE	5281	Woods Pond	125	K, O, M2, P	10/14/96	Yellow perch	COMP	10	9.38	30.0	Aroclor
GE	5282	Woods Pond	125	K, O, M2, P	10/14/96	Yellow perch	COMP	10	9.25	26.0	Aroclor
GE	5283	Woods Pond	125	K, O, M2, P	10/14/96	Yellow perch	COMP	10	9.09	26.0	Aroclor
GE	5284	Woods Pond	125	K, O, M2, P	10/14/96	Yellow perch	COMP	10	9.39	29.0	Aroclor
GE	5285	Woods Pond	125	K, O, M2, P	10/14/96	Yellow perch	COMP	10	9.23	35.0	Aroclor
GE	5286	Woods Pond	125	K, O, M2, P	10/14/96	Yellow perch	COMP	10	9.14	27.0	Aroclor
GE	5287	Woods Pond	125	K, O, M2, P	10/14/96	Yellow perch	COMP	10	9.42	29.0	Aroclor
GE	10333	Woods Pond	125	K, O, M2, P	09/27/00	Bluegill	COMP	7	5.471	26.0	Aroclor
GE	10334	Woods Pond	125	K, O, M2, P	09/27/00	Bluegill	COMP	7	5.914	26.0	Aroclor
GE	10335	Woods Pond	125	K, O, M2, P	09/27/00	Bluegill	COMP	7	6.043	25.0	Aroclor
GE	10336	Woods Pond	125	K, O, M2, P	09/27/00	Bluegill	COMP	7	5.914	25.0	Aroclor
GE	10337	Woods Pond	125	K, O, M2, P	09/27/00	Bluegill	COMP	7	5.886	32.0	Aroclor
GE	10338	Woods Pond	125	K, O, M2, P	09/27/00	Bluegill	COMP	7	5.886	28.0	Aroclor
GE	10339	Woods Pond	125	K, O, M2, P	09/27/00	Bluegill	COMP	7	5.9	33.0	Aroclor
GE	10340	Woods Pond	125	K, O, M2, P	09/27/00	Largemouth bass	COMP	10	6.72	23.0	Aroclor
GE	10341	Woods Pond	125	K, O, M2, P	09/27/00	Largemouth bass	COMP	10	6.83	25.0	Aroclor
GE	10342	Woods Pond	125	K, O, M2, P	09/27/00	Largemouth bass	COMP	10	6.81	28.0	Aroclor
GE	10343	Woods Pond	125	K, O, M2, P	09/27/00	Largemouth bass	COMP	10	6.74	21.0	Aroclor
GE	10344	Woods Pond	125	K, O, M2, P	09/27/00	Largemouth bass	COMP	10	6.86	26.0	Aroclor
GE	10345	Woods Pond	125	K, O, M2, P	09/27/00	Largemouth bass	COMP	10	7.04	23.0	Aroclor

Appendix A. Fish and Crayfish Data Used to Estimate Dose of PCBs to Kingfishers

Data Source	Sample Identity	Location	River Mile	Burrows Located Within 1200 m[a]	Date Collected	Species	Sample Type	Number Individ-uals[b]	Average Length (cm)	Concentra-tion of Total PCBs (ppm, wet weight)	Analytical Method
GE	10346	Woods Pond	125	K, O, M2, P	09/27/00	Largemouth bass	COMP	10	6.93	22.0	Aroclor
GE	10347	Woods Pond	125	K, O, M2, P	09/27/00	Yellow perch	COMP	5	7.78	30.0	Aroclor
GE	10348	Woods Pond	125	K, O, M2, P	09/27/00	Yellow perch	COMP	5	8.02	33.0	Aroclor
GE	10349	Woods Pond	125	K, O, M2, P	09/27/00	Yellow perch	COMP	5	8.02	32.0	Aroclor
GE	10350	Woods Pond	125	K, O, M2, P	09/27/00	Yellow perch	COMP	5	8.06	28.0	Aroclor
GE	10351	Woods Pond	125	K, O, M2, P	09/27/00	Yellow perch	COMP	5	8.14	29.0	Aroclor
GE	10352	Woods Pond	125	K, O, M2, P	09/27/00	Yellow perch	COMP	5	8.16	28.0	Aroclor
GE	10353	Woods Pond	125	K, O, M2, P	09/27/00	Yellow perch	COMP	5	8.14	31.0	Aroclor

Notes:

a. Geographic Information System used to determine which burrows are located within 1200 m of the river mile where samples were collected

b. Number of individuals included in composite samples

GE - data collected on behalf of General Electric Company by Blasland Bouck & Lee, Inc., in support of the RCRA Facility Investigation

USEPA = data collected on behalf of USEPA and reported in USEPA 2002

WWTP = wastewater treatment plant

COMP = composite sample

INDIV = sample comprised of a single organism

E = E-KM01

G = G-KM07

H = H-KM08

J = J-KM04

K = K-WP

M2 = M2-WP

N = N-KM16

O = O-WP

P = P-WP

Appendix B

Kingfisher Nesting Records

Appendix B. Kingfisher Nesting Record

Burrow Number: E-KM01 GPS Location: Date of Burrow Discovery: 5/8/2002

Segment ID: KM01

Description of nest including map/picture of location: In sluffing bank, behind downed Hemlock tree, not visible from river, nest appears in good condition inside

Territory: 1

Height: 7'

Distance from top of bank: 3.5'

Depth of Burrow: 4'6"

Soil Type: Predominantly sand

Bank: 7

* Recorded on video

**Digital Picture taken on 6/13/2002

		Estimated/Confirmed/Predicted
Egg date:	5/20/2002 (E)	(initiation of incubation)
Hatch date:	6/10/2002 (C)	
Fledge date:	7/7/2002 (P)	

Date	Initials of Observers	# of Eggs	# of Young	Mortality	Comments (include observations of parental behavior, nest contents)
5/8/2002	KM/TM	-	-	-	M+F birds in area and territorial. Courting.
5/10/2002	KM/TM/Kev.M	-	-	-	Walk up, inspect burrow. Appears likely. On departure - Adult flies
					from burrow and up river.
5/23/2002	KM/TM/BR	-	-	-	Probe burrow - Adult sitting in nest cavity, appears to be incubating? No
					burrow measurements were taken in fear of disturbance.
					Other adult was not seen in area or heard.
6/10/2002	KM/RB/TM	2+			Probe Burrow - Bird on nest, did not flush, did not video
6/12/2002	KM/TM	-	5+	-	Probe burrow for 3.5 min. - F on nest brooding. Young are 2 days old. M
					returns to area during video w/ fish. Flies overhead
					repeatedly, rattling aggressively. Eventually loses/eats fish.
					Retreat to lessen stress, M goes to entrance while exiting.
6/24/2002	KM/TM		6		1 Adult present, young approx. 14 days old
6/27/2002	KM/TM		6		No adults present, young approx. 17 days old (fledge expected 7/8)
7/7/2002	KM/TM		6	0	all 6 fledglings survived to 26 days (100% success); both adults present

Appendix B. Kingfisher Nesting Record

Burrow Number: G-KM07 GPS Location: Date of Burrow Discovery: 5/8/2002

Segment ID: KM07

Description of nest including map/picture of location: Faces East, under some overhanging roots. New nest materials on floor of egg cavitiy.

Territory: 3

Height: 11'

Distance from top of bank: 1'

Depth of Burrow: 4'

Soil Type: Predominantly sand

Bank: 39

*Recorded on video

** Need picture of burrow Will send Pix

Estimated/Confirmed/Predicted

Egg date: 6/5/2002 (C)

Hatch date: 6/26/2002 (C)

Fledge date: 7/24/2002 (P)

Date	Initials of Observers	# of Eggs	# of Young	Mortality	Comments (include observations of parental behavior, nest contents)
5/8/2002	KM/TM	-	-	-	Adult bird in area and territorial. On limb 40' from burrow. Flying slightly
					South then turning and going North.
5/10/2002	KM/TM/Kev.M	-	-	-	Adult bird in area and territorial. Perched across river from burrow.
					Again, flies North.
5/23/2002	KM/TM/BR	0	0	0	M+F Birds perched around burrow. Probe burrow - excellent in its
					appearance. Fresh cavity material. Birds acting extremely
					territorial (diving and rattling heavily). Fly North, up river.
6/10/2002	KM/RB/TM	-	-	-	Probe Burrow - 1 adult sitting tight on nest, cannot see nest contents
6/12/2002	KM/TM	1+	-	-	1 Adult on nest sitting tight. 1 egg is visible on its side. Bird does not
					move in 10 min. of video.
6/24/2002	KM/TM				Adult female incubating eggs; cannot see eggs or young, recorded 10 min. video
6/27/2002	KM/TM		4+		Both parents near burrow entrance; young approx. 1 day old
7/7/2002	KM/TM	1 (addled)	0	4+	Nest depredated

Appendix B. Kingfisher Nesting Record

Burrow Number: H-KM08 GPS Location: 18T: 0644990 N 42 deg. 24.300' Date of Burrow Discovery: 5/8/2002

Segment ID: KM08 W 73 deg. 14.289'

Description of nest including map/picture of location: Faces North, under some overhanging grassy bank material. New nest material on floor of egg cavity.

Bank: 43

Dimensions of Burrow: 3.75" wide x 4.5" tall

Height: 7.5'

Distance from top of bank: 1'

Depth of Burrow: 3'7"

Soil Type: Sand/clay mix - dark black in color

Territory: 4

*Recorded on video

**Digital picture taken 5/23/2002

Estimated/Confirmed/Predicted

Egg date: 5/27-5/29/2002 (C) (initiation of incubation)

Hatch date: 6/20/2002 (C)

Fledge date: 7/17/2002 (C)

Date	Initials of Observers	# of Eggs	# of Young	Mortality	Comments (include observations of parental behavior, nest contents)
5/8/2002	KM/TM	-	-	-	No birds in area, feel it could possibly be an alternate burrow for pair of adults at BEKI-G?
5/10/2002	KM/TM/Kev.M	-	-	-	Adult bird in area Perched next to burrow on dead limb. Flushes and flies South. BEKI-G birds flew North (different bird!)
5/23/2002	KM/TM/BR	1	0	0	No birds in area. Probe burrow - excellent in its appearance, fresh egg cavity nest material. 1 egg in cavity. 2 adult birds flushed South of burrow as we continue down river and fly North towards burrow (BEKI-G birds were North to our knowledge)
6/10/2002	KM/RB/TM	1+	0	-	Probe Burrow - 1 Adult on nest sitting tight, does not expose anymore contents
6/12/2002	KM/TM	-	-	-	1 Adult on nest. Sitting broadside but showing no eggs/young. Egg cavity is very large. No movement in 10 min. of video.
6/24/2002	KM/TM		5		Young are 2-3 days old
6/27/2002	KM/TM		6		Young are 5-6 days old
7/7/2002	KM/TM		6		Young are 15-16 days old
7/17/2002	TM/DD/CW	0	4	1	Young Fledged at 26 days old, 4 seen around area upon arrival, 1 killed by predator across from burrow on opposite shore, 0 left in burrow when probed

Appendix B. Kingfisher Nesting Record

Burrow Number: J-KM04 GPS Location: 18T: 0645‹ N 42 deg 25.255 Date of Burrow Discovery: 5/8/2002
Segment ID: KM04 W 73 deg. 13.905'
Description of nest including map/picture of location: Faces North, on steep soil pile in Noble farm fi
~30 ft up from ground. Nest cavity is fresh and in good condition.
Bank: 23
Territory: 2
Height: 24.5'
Distance from water: ~ .3 miles
Distance from top of bank: 1.5'
Depth of Burrow: 2'
Soil Type: Clay/Silt/Sand mix, "top soil" - dark black in color

*Recorded on video
**Digital picture taken 5/23/2002
Estimated/Confirmed/Predicted
Egg date: 5/27-5/29/2002 (C) (initiation of incubation)
Hatch date: 6/16/2002 (E)
Fledge date: 7/15 (P)

Date	Initials of Observers	# of Eggs	# of Young	Mortality	Comments (include observations of parental behavior, nest contents)
5/8/2002	KM/TM	-	-	-	M+F adult birds inspecting two banks/piles stockpiled in Noblr farm field.
					Courting, both inspecting multiple sites and burrows
5/17/2002	TM/Kev.M	-	-	-	No birds present. Access piles via vehicle. Park and walk to piles. 2 new
					burrows have been excavated - 1 in each pile.
5/22/2002	KM/TM	-	-	-	Access via vehicle and walk. M adult in area trees - flushes to river. Sit
					and observe. M repeatedly observed returning to piles and
					flies into burrow in the black topsoil bank for 15 minutes.
5/23/2002	KM/TM	1	0	0	One bird flushes from trees upon arrival. Faces Northwest. Probe burrow
					- egg cavity is fresh and in good condition. 1 egg present.
6/11/2002	KM/TM/KK	-	-	-	1 Adult on nest, still a short burrow. Adult sitting tight w/ no contents
					visible.
6/13/2002	KM/TM	3+	-	-	1 Adult on nest. Sitting tight w/ brood patch exposed to cover eggs initially.
					At 2 min. mark the adult attacks the camera by snapping at
					it, stands - showing some (3+), of her eggs. 4.5 min mark is
					a second attack at which we exit burrow and area.
6/24/2002	KM/TM		3-4		No adults present. Young appear 8 days old
6/27/2002	KM/TM		5		Young are 10 days old, expected to fledge 7/16
7/7/2002	KM/TM		5		Young are 20 days old, one missing since last visit
7/13/2002	KM/TM		5		All four young survived to 26 days

Appendix B. Kingfisher Nesting Record

Burrow Number: K-WP   GPS Location: 18T: 0644807 N 42 deg. 20.469'   Date of Burrow Discovery: 5/23/2002

Segment ID: WP01/WP02   W 73 deg 14.496'

Description of nest including map/picture of location: Faces East, on steep sand cut bank in Lane Construction quarry. ~ 50 from ground, nest cavity is fresh

Bank: 123

Height: 65'

Distance from water: ~ .4 miles

Distance from top of bank: 2'3"

Depth of Burrow: 4'3"

Soil Type: Predominantly Sand

*Recorded on video

**Digital picture taken 5/24/2002

Estimated/Confirmed/Predicted

Egg date: 5/21/2002 (E) (Initiation of incubation)

Hatch date: 6/11/2002 (C)

Fledge date: 7/9/2002 (P)

Date	Initials of Observers	# of Eggs	# of Young	Mortality	Comments (include observations of parental behavior, nest contents)
5/23/2002	KM/TM	-	-	-	Burrow observed and labeled as "good possibility." Hours of observations
					w/ no bird sightings or calls.
5/24/2002	KM/TM	1+	-	-	1 adult flies through area upon approach to burrow. Probe burrow -burrow
					and egg cavity appear in good condition. 1 M adult sitting on
					nest. One egg can be seen.
6/11/2002	KM/TM	-	-	-	Observed and exchange w/ birds flying to Woods Pond
6/12/2002	KM/TM	1+	3+	-	Adult on nest - no movement in 12 min. of video. Young are 1 day old.
6/24/2002	KM/TM		3+		Young are 13-14 days old; 4th young may be present but not sure
6/27/2002	KM/TM		3		young are 16 days old; no adults present
7/7/2002	KM/TM		3		All young survived to 26 days; adults not present

Appendix B. Kingfisher Nesting Record

Burrow Number: M-WP GPS Location: N 42deg. 20.694' Date of Burrow Discovery: 5/22/2002

Segment ID: WP01/WP02 W 73 deg. 14.501'

Description of nest including map/picture of location: Faces South, on steep sand cut bank in Lane Construction quarry. ~ 60 from ground, nest cavity is fresh

Bank: 95

Distance from water: ~ .3 miles

Height: 82'

Distance from top of bank: 4'

Depth of Burrow: ~4.5'

Soil Type: Sand

*Not Recorded on video due to accessibility and rain

**Digital picture taken 5/24/2002

Estimated/Confirmed/Predicted

Egg date:

Hatch date:

Fledge date:

Date	Initials of Observers	# of Eggs	# of Young	Mortality	Comments (include observations of parental behavior, nest contents)
5/22/2002	KM/TM	-	-	-	Burrow observed and labeled as "good possibility." Hours of observations
					w/ no bird sightings or calls.
5/23/2002	KM/TM	-	-	-	Hours of observation w/ no sightings or calls
5/24/2002	KM/TM	1+	-	-	1 adult flies through area, and circles around upon approach to burrow.
					Probe burrow - burrow and egg cavity appear in good
					condition. 1 adult sitting on nest. One egg can be seen.
6/11/2002	KM/TM	0	0	1+	Nest burrow has been destroyed since last observation. Bank has been
					excavated from below and sloughed greatly. No visible
					remains of the original burrow.

Appendix B. Kingfisher Nesting Record

Burrow Number: M2 -WP   GPS Location: Date of Burrow Discovery: 6/11/2002

Segment ID: WP01/WP02

Description of nest including map/picture of location: Faces West, on steep sand cut bank in Lane Construction quarry. ~15 feet vertical slope, nest

Bank: 105

Height: 28'

Distance from water: ~ .3 miles

Distance from top of bank: 3.5'

Soil Type: Sand

*Recorded on video

**Digital picture taken 6/12/2002

Estimated/Confirmed/Predicted

Egg date: 6/24-6/29/2002 (E)

Hatch date: 7/15-720/2002 (E)

Fledge date: 8/12-8/17/2002 (P)

Date	Initials of Observers	# of Eggs	# of Young	Mortality	Comments (include observations of parental behavior, nest contents)
6/11/2002	KM/TM	-	-	-	Both M and F adults in a bank w/ 2-3 possible burrows. Birds seen both
					courting and copulating. Appears to be original BEKI-M
					pair starting to re-nest.
					Observed an exchange w/ birds flying to Woods Pond
6/12/2002	KM/TM	-	-	-	1 Adult on nest - possibly standing. Cannot see contents of nest, bird does
					not flush.
6/24/2002	KM/TM	2+			1 adult on nest; 2 eggs visible in front of breast; snaps at camera
6/27/2002	KM/TM	-	-		1 adult on nest; no eggs or young visible
7/7/2002	KM/TM				1 adult on nest; no eggs or young visible
7/16/2002	TM				Depredated, likely by avian predator

Appendix B. Kingfisher Nesting Record

Burrow Number: N-KM16 GPS Location: N 42 deg 22.061' Date of Burrow Discovery: 6/10/2002

Segment ID: KM16

Description of nest including map/picture of location: On East side of October Mountain Road. Burrow was previously investigated at earlier visits and was too small for birds/camera. Faces out to the river, tucked under rocks and root masses. Surrounding area is farmer's field above burrow.

Bank: 87

Height: 15'

Distance from water: 48'

Distance from top of bank: 2'

Soil Type: Sand

*Recorded on video

**Digital picture taken

Estimated/Confirmed/Predicted

Egg date:

Hatch date:

Fledge date:

Date	Initials of Observers	# of Eggs	# of Young	Mortality	Comments (include observations of parental behavior, nest contents)
6/10/2002	KM/RB/TM	-	-	-	Male adult on nest, sitting tight, no contents could be seen. Mate seen in
					area rattling aggressively.
6/13/2002	KM/TM	-	-	-	1 Adult in tree above burrow upon arrival - flies away rattling. Probe
					Burrow - 1 adult on burrow sitting tight, cannot see any nest
					contents. First adult upon arrival continually flies above area
					rattling aggressively. Exit area to lessen stress in 3.5 min.
6/24/2002	KM/TM	1?	-	-	1 adult on nest incubating and blocking view of most eggs
6/27/2002	KM/TM	5			Nest depredated by mustellid (adults punctured behind skull; male skull gone

Appendix B. Kingfisher Nesting Record

Burrow Number: O-WP | GPS Location: | Date of Burrow Discovery: 6/11/2002

Segment ID: WP01/02

Description of nest including map/picture of location: Faces West, on steep sand cut bank in Lane Construction quarry. Northernmost burrow, ~ 10 from

Bank: 129

Height 21'

Distance from water: ~ .5 miles

Distance from top of bank: 4.5'

Soil Type: Sand

*Recorded on video

**Digital picture taken 6/12/2002

Estimated/Confirmed/Predicted

Egg date:

Hatch date: 6/10/02 (E)

Fledge date: 7/9/02 (P)

Date	Initials of Observers	# of Eggs	# of Young	Mortality	Comments (include observations of parental behavior, nest contents)
6/11/2002	KM/TM	-	-	-	Probe Burrow w/ ladder - adult bird aggressively lunges and snaps at the
					camera as it enters the burrow. Bird does not back down or
					away. Pull out and leave. Numerous flies seen flying around
					burrow entrance.
					Observed an exchange w/ birds flying to Woods Pond.
6/12/2002	KM/TM	-	-	-	1 Adult bird on nest w/ same aggression. Would not allow camera in the
					burrow, snaps at the camera and walks it out to the entrance.
					Stop after one attempt to lessen stress.
6/24/2002	KM/TM	0	3		No adults present. Young are 13-14 days old
6/27/2002	KM/TM		4		Young are 16 days old; adult present with fish
7/7/2002	KM/TM		4		Young are 26 days old; 100% survival; 1 adult in area with fish

Appendix B. Kingfisher Nesting Record

Burrow Number: P-WP   GPS Location: N 42 deg., 20.609', W 73 deg 14.366'   Date of Burrow Discovery: 6/11/2002

Segment ID: WP01/WP02

Description of nest including map/picture of location: Faces South, on sloping sand cut bank in Lane Const ruction quarry. Located in close proximity to

Bank: 114

Height: 18'

Distance from water: ~ .3 miles

Distance from top of bank: 2'

Soil Type: Clay/Sand

*Recorded on video

**Digital picture taken 6/12/2002

Estimated/Confirmed/Predicted

Egg date: 6/12/2002 (E)

Hatch date: 7/3/2002 (E)

Fledge date: 7/31/2002 (P)

Date	Initials of Observers	# of Eggs	# of Young	Mortality	Comments (include observations of parental behavior, nest contents)
6/11/2002	KM/TM	-	-	-	1 Adult on nest sitting tight. Possibly fecal matter around breast of bird.
					Observed an exchange - birds flying to Woods Pond.
6/12/2002	KM/TM	-	-	-	1 Adult on nest, sitting tight. Possible fecal matter seen, but no young
					visible. No movement in 10 minutes of video.
6/24/2002	KM/TM	-	-	-	1 adult on nest, sitting tight. No eggs visible
6/27/2002	KM/TM	-	-	-	1 adult on nest, sitting tight, tail points up, incubating; no eggs or young visible
7/7/2002	KM/TM		4+		1 adult w/fish outside of burrow; nestlings 4 days old
7/16/2002	TM		5		1 Adult returns from Woods Pond; very vocal young; one aggressive -
					walks towards front of burrow
7/26/2002	TM		2	2	2 young at 23 days old; no adults around; one awake and lively
7/29/2002	TM/CW		2	2	2 young at 26 days old; ready to leave nest; no adults around